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**CORNELL UNIVERSITY**  
*Center for Radiophysics and Space Research*

ITHACA, N. Y.

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CENTER FOR RADIOPHYSICS AND SPACE RESEARCH  
CORNELL UNIVERSITY  
ITHACA, NEW YORK

④ April 30, 1962

⑥ CRSR 118

Final Report to  
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH  
for

③ Theoretical Research  
in Astrophysics

Contract AF49(638)-915

## 1. General Scope

This contract was in operation from June 1, 1960 to March 31, 1962. Seven graduate students and three research associates were supported for varying periods by this contract, and worked under the direction of Professors Gold, Salpeter, Morrison and Booker. One Ph.D's thesis and two Master's theses as well as various other reports and papers have come from this work.

## 2. The Abundance of Molecular Hydrogen in the Galaxy

An investigation was made of the detailed processes that lead to association of atomic hydrogen on the surfaces of galactic dust grains, and of the rates at which this might be expected to produce molecular hydrogen on a galactic scale. The rates of dissociation by ultraviolet light were investigated and the conditions under which this dissociation rate would be significant were found to be chiefly in the streaming between bright blue stars and the interstellar gas. The equilibrium between association and dissociation that must be expected in the galaxy seems to occur for a much greater abundance of molecular hydrogen than had previously been suspected.

Reports or papers presented:

R. J. Gould - C.R.S.R. 108 - "The Interstellar Abundance of the Hydrogen Molecule" (To be published in the March, 1962 issue of the Astronomical Journal).

R. J. Gould - "The Interstellar Abundance of the Hydrogen Molecule" - Ph.D. dissertation under preparation.

### 3. The Hydrogen Atmosphere of the Moon

The effect of proton bombardment of the moon's surface from the sun and the subsequent thermal re-evaporation of hydrogen gas have been investigated. It was concluded that most of this gas would escape from the surface within a short time as neutral atomic hydrogen. Owing to the slow speed of the re-evaporating gas, the density would be several hundred times greater than the density of the high speed incoming gas and this implies the possibility of detection through Lyman  $\alpha$  scattering.

Reports and papers presented:

R. J. Gould - C.R.S.R. 114 - "Hydrogen Near the Moon"

T. Gold - Paper to be delivered at the COSPAR Meeting, May, 1962.

### 4. The Interaction of a Tenuous Plasma with an Antenna

Theoretical investigations were carried out to determine the plasma sheath effects and their electromagnetic consequences around an antenna placed in a very tenuous plasma. Calculations were made both for a static case and for the case that the plasma has a high relative velocity to the antenna. The electromagnetic propagation characteristics were investigated through the plasma sheath. It is one important application of such work to find means of measuring plasma densities by measuring impedances of antennas.

Reports and papers presented:

S. Peale - CRSR 116 - "Plasma Sheaths and their Effects on Antenna Impedance Measurements of Electron Density" - Master's thesis, May, 1962.

5. Infrared Astronomy

A variety of calculations were made to determine the most fruitful experimentation from a high altitude to observe the infrared emission from galactic dense clouds. The total amount of energy that could be radiated by such clouds is very large and it may prove to be a very important step in observational astronomy to detect this emission. The technical difficulties are great as the observational apparatus would need to be at a high level in the atmosphere, and at the same time be of considerable complexity. The subject is being pursued further.

6. Plasma and Magnetic Fields in the Solar System

Studies of plasma and energetic particle effects in the solar system are under way. The model of a tongue of magnetic field extending outwards from the sun is being investigated further as are the effects of turbulence and shock waves. This work continues.

7. Magnetic Effects of Geomagnetically Trapped Particles

A method of calculating the geomagnetic effects of trapped particles has been devised and detailed calculations have been carried out. The object was mainly to obtain the change in the field at the surface of the earth resulting from the various shells of possible particle fluxes from a close distance above the earth's surface out to 10 earth radii. Calculations have been carried out on an NASA computing machine (IBM 7090) and

the results have been assembled in such a way that without any further machine computation it will be possible to obtain the field deviation anywhere on the surface of the earth for an arbitrary distribution of intensity of particle fluxes in the magnetosphere.

Reports and papers presented:

M. L. Dwarkin - C.R.S.R. 117 - "Magnetic Effects of Geomagnetically Trapped Particles" - Master's Thesis, May 1962.

#### 8. General Relativity

Work in general relativity on certain problems of gravitational waves is in progress. Prof. I. Robinson for the present year at the Center for Radiophysics and Space Research has been the co-author of a paper on "Asymptotic Properties of a System with Non-Zero Total Mass" which has been submitted by Prof. P. G. Bergmann of Syracuse University. Prof. Robinson has been supported in part by this contract.

#### 9. Dynamics of Grains

An investigation of the motion of interstellar and interplanetary grains has been started. The work has been divided into two sections:

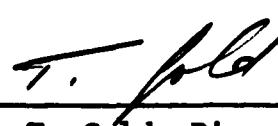
a) The influence of radiation pressure in producing instability of cosmic clouds and star formation has been investigated. It appears that radiation pressures may play a considerable role in producing star formation in the vicinity of bright

young stars. The process described compares in efficiency with the Oort-Spitzer "rocket" process which compresses clouds to produce instability. Radiation pressure may also be effective in accelerating interstellar clouds and in producing gas outflow from the nucleus of galaxies. This work has now been completed. It is to be published as a C.R.S.R. report and will, in addition, be submitted for publication in one of the professional journals.

b) The motion of interplanetary grains has been under investigation. It appears that solar light pressure is instrumental in ejecting large quantities of comet debris from the solar system. A further tentative result indicates that the terrestrial capture of interplanetary grains is facilitated by solar radiation pressure. This study is being prepared for publication but a number of important details still need to be more thoroughly investigated.

Reports and papers presented:

M. O. Harwit, C.R.S.R. 119 - "Dust, Radiation Pressure and Star Formation", May, 1962.

  
T. Gold, Director